

# Linac Intensity Upgrade

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V. LoDestro / D. Raparia  
November 13, 2012

## 2014 BLIP/RRPL Operations Review

# OUTLINE

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- Linac performance
- Intensity Upgrade
- RF Tubes, Strategy
- Present Status

# Acknowledgements

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J. Alessi, G. Atoian, B. Briscoe, F. Carlino, T. Flanagan,  
D. Gassner, P. Ingrassia, T. Lehn, V. Lodestro, G.  
Omar, D. Raparia, J. Ritter, W. Shaffer, A. Zelenski

## Current LINAC Beam Parameters

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■ Frequency	201.25 MHz
■ Injection Energy	0.750 MeV
■ Final Energy*	10-200 MeV
■ Peak H <sup>-</sup> Current	42 mA/ ~ .5 mA P <sup>^</sup>
■ Pulse Length	450 μs
■ Repetition Rate	6.67 Hz
■ Number of Tanks	9
■ Length	144.8 m
■ Total Peak RF Power	22 MW

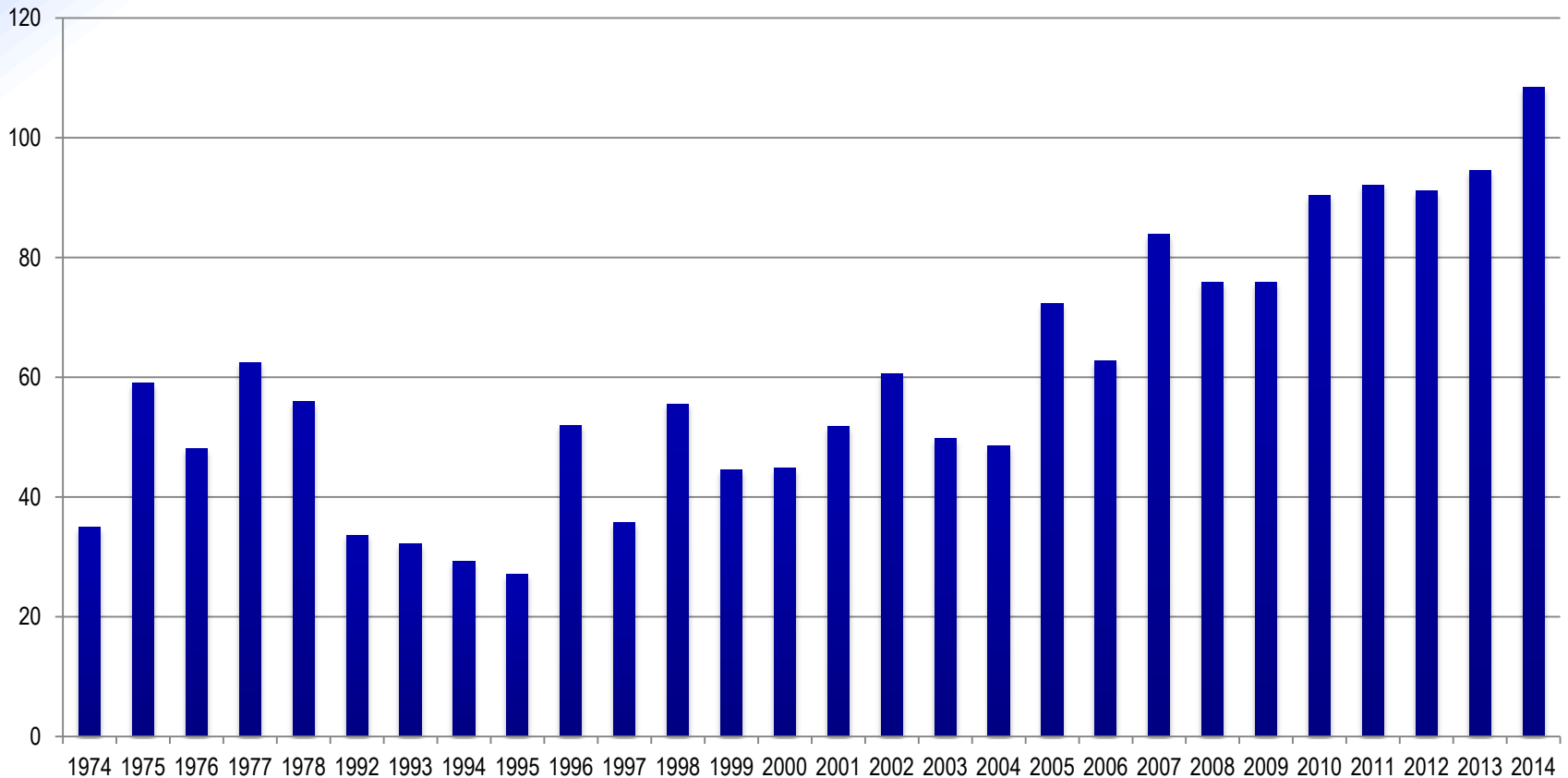
\* Energy can be changed pulse-to-pulse

# Linac Modes of Operation

Mode	BLIP (%)	RHIC(%)
Dedicated	100	0
RHIC with P <sup>^</sup>	92.5	7.5
AGS Setup/Study Day and Evening	95	5
200 MeV P <sup>^</sup> setup/study Day and Evening	91.6	8.3

# Historical Average Beam Current Delivered to BLIP

Average Current ( $\mu\text{A}$ )





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# Intensity Upgrade Phase 1

# Upgrade - Phase I

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- Increase beam current by 15%. 5% through ion source and Low Energy Beam Transport / Medium Energy Transport improvements. 10% through RF flattop increases and beam triggering.
- Evaluate the proposal to double the Linac beam current
  - Evaluate and prototype quadrupole pulse modulators flattops for 900  $\mu$ s beam
  - Evaluate conditions of water cooling channels in drift tubes and accelerator cavities
  - Prototype RF system for 1100  $\mu$ s pulse length
  - Recommend Phase 2 requirements for 240  $\mu$ A average linac beam current.
- Completion FY-2016 operations



# Doubling the Linac Current

( after 2016 )

- Note design Duty Cycle for the Linac RF is 0.4%, for Beam 0.2%

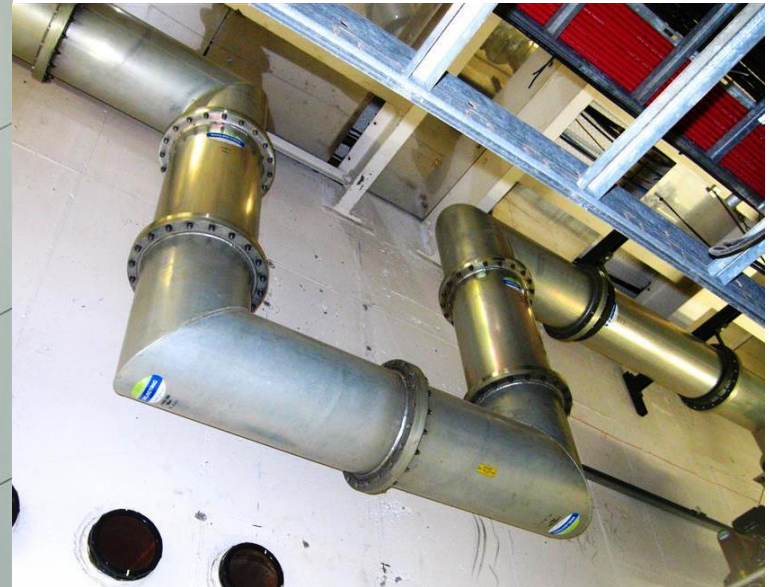
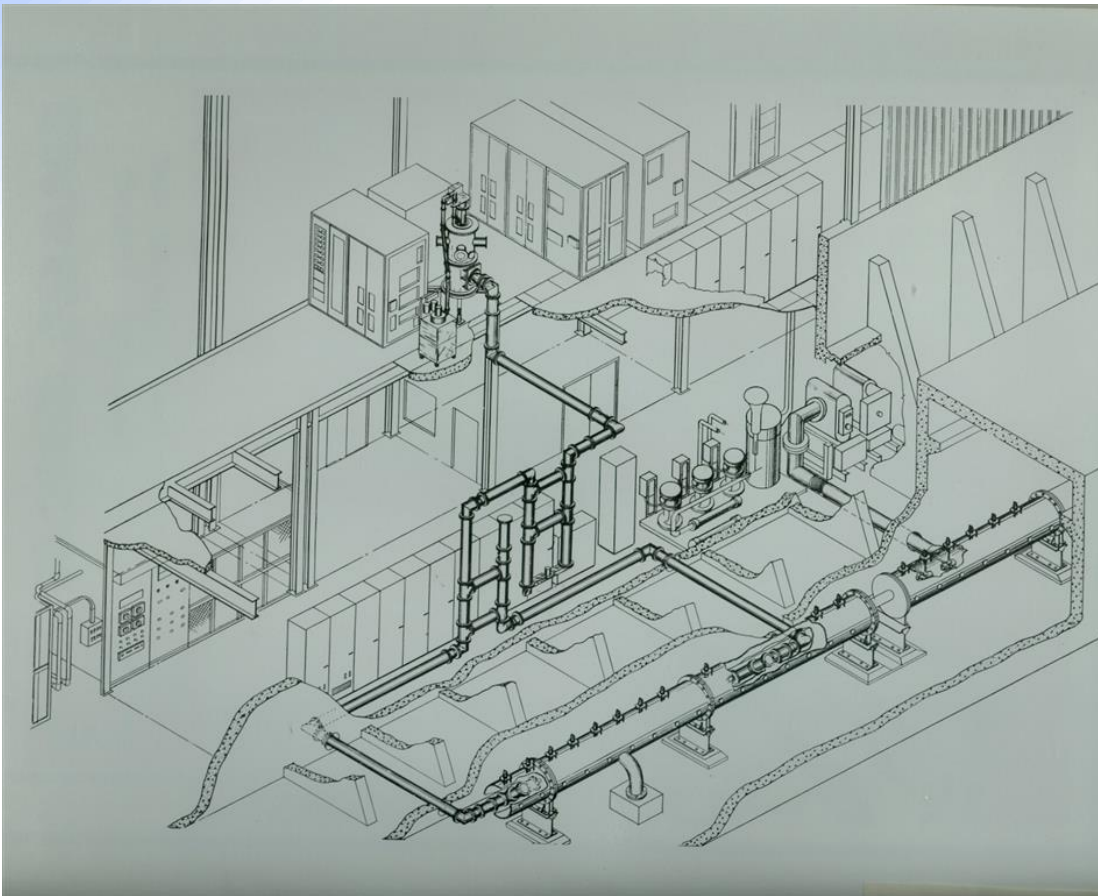
	Present	Phase 1	Phase 2
Peak Beam current	42 mA	45 mA	45 mA
Max Avg Beam current	120 $\mu$ A	140 $\mu$ A	240 $\mu$ A
Beam Pulse Length	450 $\mu$ s	480 $\mu$ s	900 $\mu$ s
RF Pulse Length	650 $\mu$ s	670 $\mu$ s	1100 $\mu$ s
RF Duty Cycle	0.43%	0.44%	0.73%
Rep. Rate	6.67 Hz	6.67 Hz	6.67 Hz

# Coax and Phase Shifter

Linac 12" Coax Transmission Line PA to Accelerator

LoDestro, Shaffer, Briscoe

U-Bend



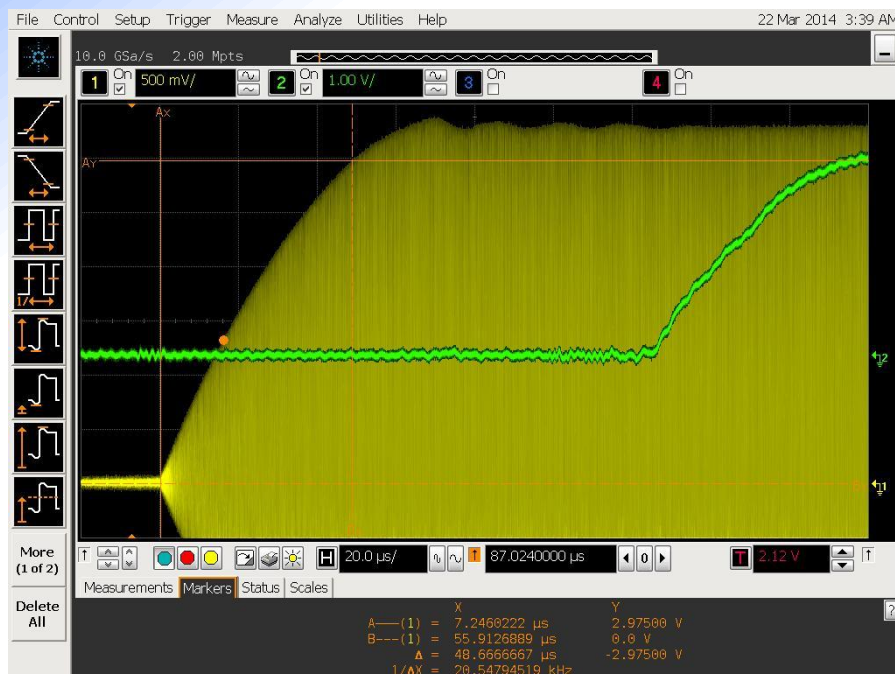
# RF Rise Time Measurements

LoDestro, Briscoe

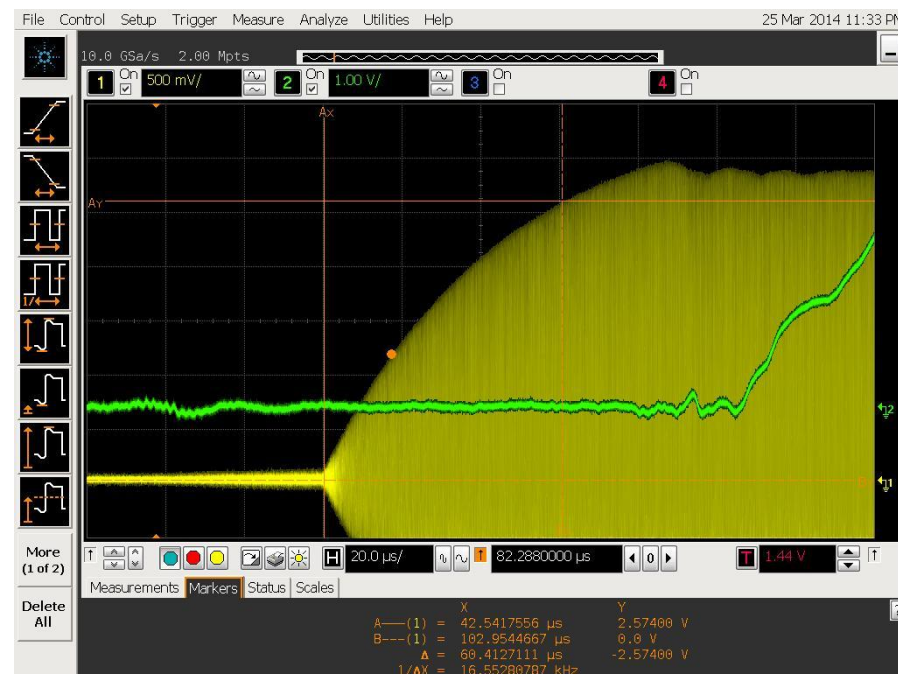
Tank #	Rise time (90%, $\mu$ s)	Beam delay ( $\mu$ s)
1	53.1	127.33
2	48.88	127.10
3	48.6	125.10
4	50.0	126.88
5	51.7	127.77
6	52.0	127.70
7	54.89	130.00
8	60.0	106.22
9	61.0	127.10

# RF Rise Time Measurements

LoDestro, Briscoe



Tank3: Rise time (90%)  $48.7 \mu\text{s}$   
 Beam delay  $125.1 \mu\text{s}$



Tank8: Rise time (90%)  $60.4 \mu\text{s}$   
 Beam delay  $106.22 \mu\text{s}$



# Phase Measurement Test Set up



Job Plan:

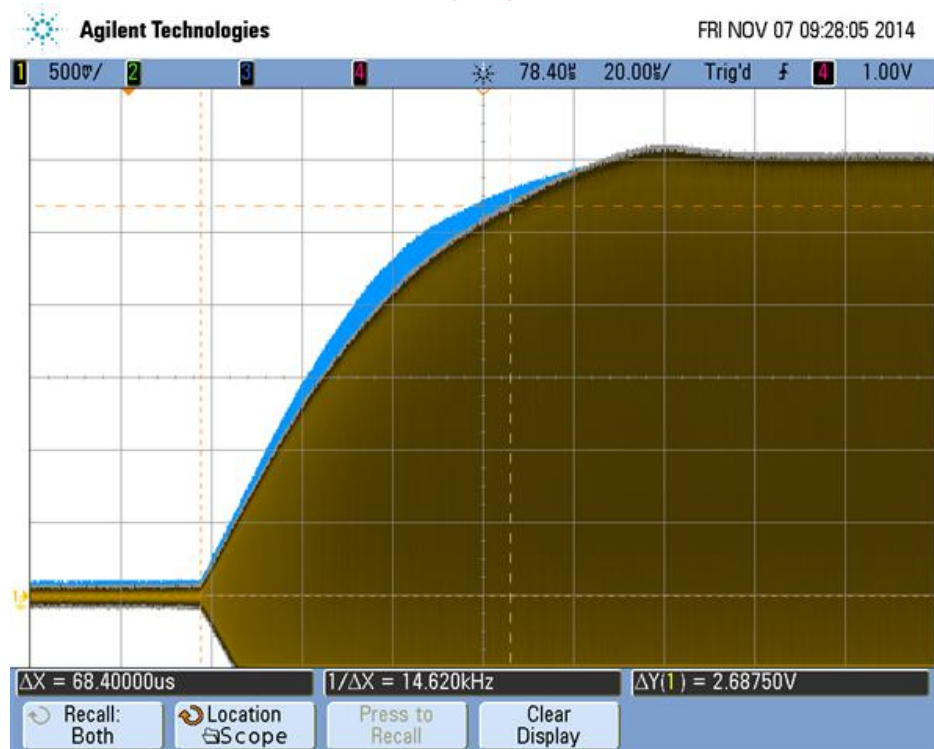
- Remove u-bend and straight sections
- Measure phase shift of removed pieces
- Install 3 1/8" phase shifter at same phase
- Operate RF System at 600 kW, adjust phase shifter for minimum linac cavity time
- Reinstall u-bend with corrected phase straight sections

fill

# Results of rise time measurement to date at 2.79 MW cavity power

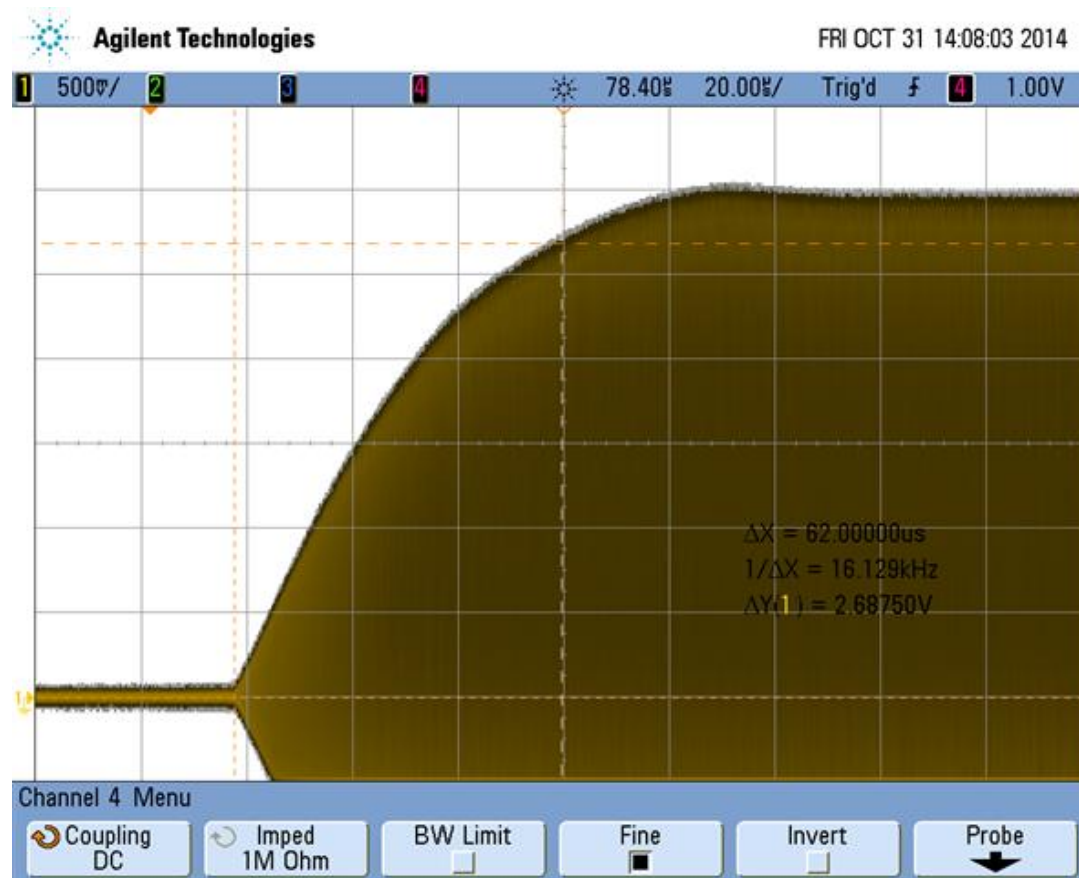
TK-8 Rise time 64  $\mu$ s +10 deg legs

TK-8 Rise time 68  $\mu$ s orig legs /  
over +10 deg legs



# Results of rise time measurement to date at 2.79 MW cavity power

- Best response, -10 degree sections will be installed in each u-bend leg





# Ion Source Test Stand

Lehn, Zelenski

Needed to evaluate the source operation with extended pulse width (duty factor)

Test stand completed with new vacuum pump and oscilloscope purchased

New gas valve electronics prototyped

New arc pulser FET switch developed

Beam delivered to test box





# Quad PS Test for Doubling the Pulse Length

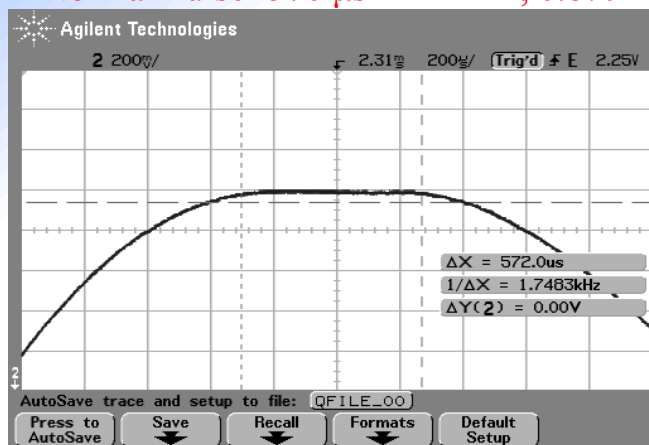
250 Amps Peak Current

Lodestro, Briscoe

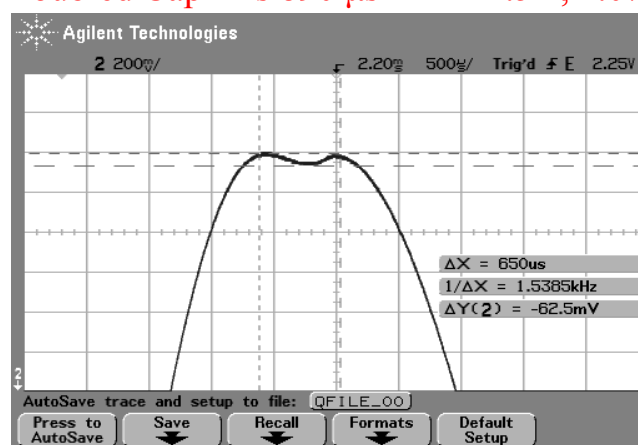
## Existing quad pulsers can't handle the extended pulse width

- Original specification 0.1% current regulation over 200  $\mu$ s beam, =25 ma

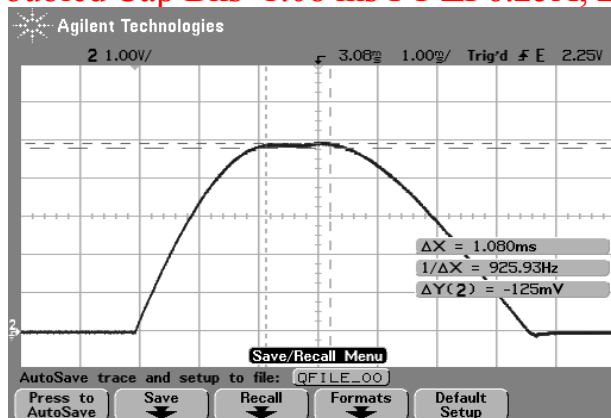
Normal Pulser 570  $\mu$ s FT  $\Delta$ I 2A, 0.8%



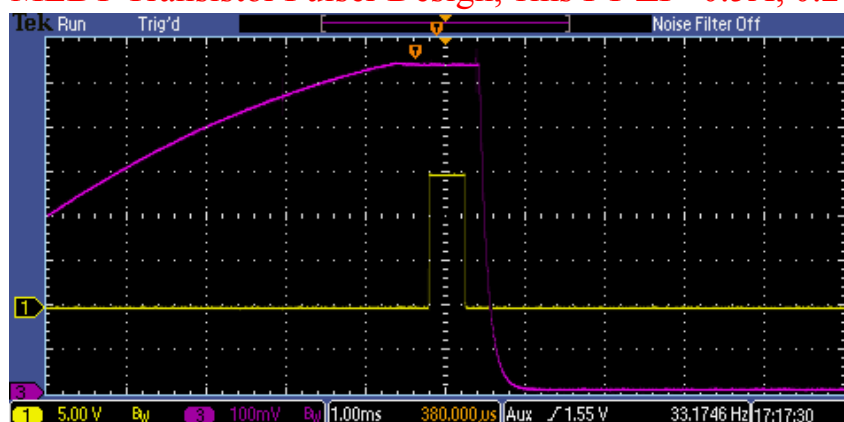
Doubled Cap Bks 890  $\mu$ s FT  $\Delta$ I 2.5A, 1.0%



Doubled Cap Bks 1.08 ms FT  $\Delta$ I 6.25A, 2.5%



MEBT Transistor Pulser Design, 1ms FT  $\Delta$ I <0.5A, 0.2%



Brookhaven Science Associates  
U.S. Department of Energy

## Water channel in tank and quad examination with borescope

- VideoScope was just received last week
- Working with vendor it was determined that the smallest industrial probe available, 2mm dia, would not be able to make the several 90 degree bends to get into a drift tube cooling passage. Tk1 drift tube 15 was attempted.
- We will continue the examination of cooling passages in drift tube stems and cavity cooling channels.



# Linac Tubes, Goal Maintain Min 5 Yr inventory of ea tube type

LoDestro

Tube Type	Ave Failure/yr	Spares	~operating yrs	FY14 k\$/tube
ML8618 (modulator)	7	37	5.2	10.4 (rebuild)
LPT-32 (Amplitude Loop)	2.3	10	4.3	7.9 (rebuild)
4CW25000 (Grid)	1.8	12	6.6	2.3 (rebuild) 5.7(New)
4616V (driver)	4	13	3.25	48.2 (rebuild) 68.0 (new)
7835 V2 (PA)	3	16	5.3	136 (~rebuild) 248(new)
7651 (pre amplifier)	14.5	23	1.6	2.6 (new)

- This year's purchases not included in the inventory
  - 8618 10 ea. LPT-32 2ea., 4CW25000 1ea.
  - 7835 2 ea., 4616 2 ea., 7651 5 ea., (PO not yet dispatched)

# Milestone Goals

On Schedule to meet our Dec 2014 Goals

3 Month Goals	Project Funded April 2014
09/2014	<ol style="list-style-type: none"><li>1. Complete quad pulse flattop extension analysis <b>Complete</b></li><li>2. Complete specifications and submit web requisitions, all coax components and fabrication contract, Borascope, Source vacuum pump, energy storage capacitors, crowbar ignitrons <b>Complete</b></li><li>3. Work Plan coax modifications to U-Bends <b>Complete</b></li></ol>
12/2014	<ol style="list-style-type: none"><li>1. Rework Coax U-Bends in RF Modules 2 – 4</li><li>2. Borascope a sampling of tank drift tube and cavity cooling channels for erosion</li></ol>
03/2015	<ol style="list-style-type: none"><li>1. Prepare simulated drift tube w/quad for temperature rise measurement</li><li>2. Specify and order P.S. for Modulator and Driver extended duty test</li></ol>
06/2015	<ol style="list-style-type: none"><li>1. Modify RF Test Bay, 10<sup>th</sup> System, for extended duty testing. System testing begins.</li></ol>
09/2015	<ol style="list-style-type: none"><li>1. Complete Mod 10 RF system testing</li><li>2. H- Source Test Stand completed, source testing begins for current increases</li></ol>
12/2015	<ol style="list-style-type: none"><li>1. Install Coax U-Bends in RF Modules 6 – 9 complete</li><li>2. Complete tank quad temperature rise measurement using Tank 1 cavity cooling station</li></ol>
06/2016	<ol style="list-style-type: none"><li>1. Linac tuned for 15% intensity increase.</li></ol>
09/2016	<ol style="list-style-type: none"><li>1. Prepare final report on project results and make recommendations for Phase II</li></ol>

# Summary: Intensity Upgrade Phase I (AIP)

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- Work is on schedule and within planned cost

## 15% intensity increase:

- Test Stand ion source is operating, new gas valve PS is being tested, new vacuum pump is installed
- RF rise time for all 9 system has been measured
- Optimizing coax lengths to minimize rise time and beam delay is in process. We are meeting our milestone goals.

## Evaluation of pulse length doubling:

- Present quadrupole PS will not support 900  $\mu$ s pulse length. We have received engineering quote for new PS's based on our specification (~10k\$ each 50K NRE)
- Examinations for water channels in tanks and quad has started, expected to finish before run starts.

# Back up slides



# Phase Shifters

## ■ 12" Coax



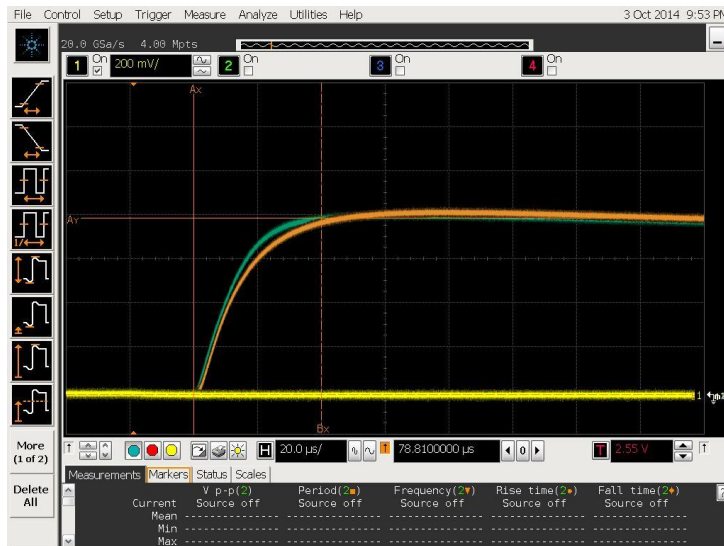
## 3 1/8" Coax



# Results of rise time measurement to date

- Moving the 12" phase shifter to replace each ubend was determined to be unworkable due to its size, rigging, and infrastructure changes to the facility since 1995 eliminating clear and safe working access to the job. Therefore we substituted the much smaller 3 1/8" shifter measuring at a lower power level but maintaining the system phase shifts through each operational component.
- Tank 8 was the first system to be selected due to its clear access to the ubend and slow rise time.

Rise Time 40 uSec Shifter out / in



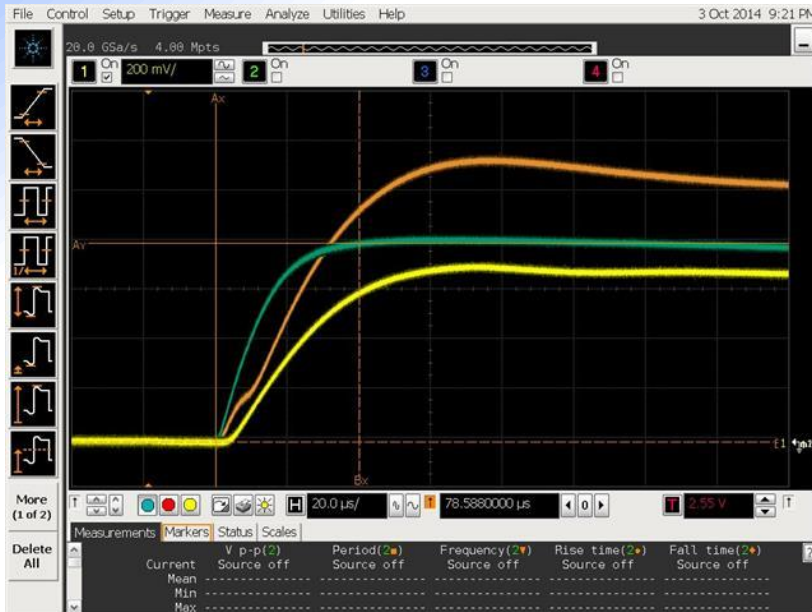
Rise Time 64 uSec -14 Degrees





## Results of rise time measurement to date

Rise time 60 uSec +25 Degrees



# This Year's Performance

